Section 1

Introduction

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1.0. Background

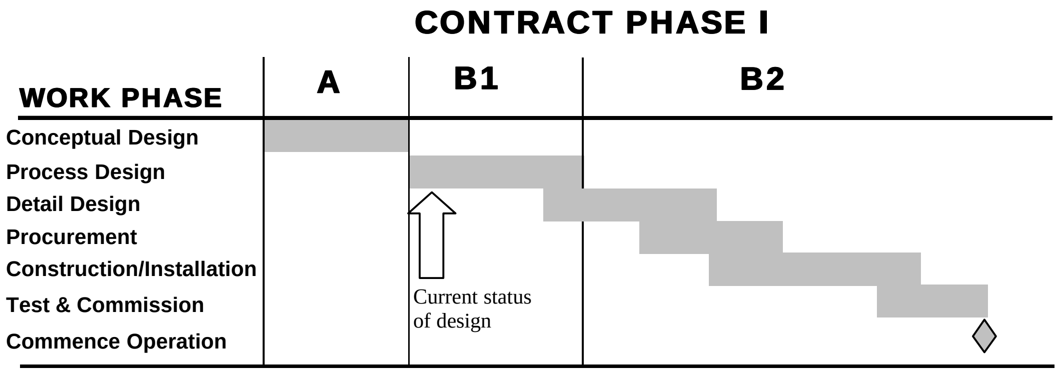
BNFL Inc. has entered into a contract with the US Department of Energy (DOE) for pretreatment and immobilization of waste currently stored in underground tanks at the Hanford Site. This contract (No. DE-AC06-96RL13308) specifies the DOE will retrieve and transfer low activity waste (LAW) and high level waste (HLW) to facilities designed, built, and operated by BNFL Inc. for pretreatment and immobilization by vitrification. BNFL Inc. will return the vitrified waste products, intermediate waste products, and some secondary wastes to the DOE for interim storage and disposal.

The DOE and its contractors manage 177 underground radioactive waste storage tanks at the Hanford Site in Richland, Washington. These tanks contain approximately 55.5 million US gal of radioactive waste, comprised of sludge (14 million US gal), saltcake (24 million US gal), and liquids (17.5 million US gal). The DOE elected to contract with a private company to provide services for treatment of these tank wastes. The DOE identifies this approach as Privatization. Privatization services will be provided in two phases. Phase I is a licensing, permitting, and commercial demonstration effort. During Phase I, 6 to 13 percent of the tank waste will be processed during a 5- to 9-year period. During Phase II, the remaining tank waste will be treated on a schedule that will remove all liquid waste from all single shell tanks (SSTs) by the year 2018.

Phase I is subdivided into Parts A and B. Phase I Part A was in effect from September 25, 1996 through May 25, 1998 and consisted of demonstrating waste treatment technologies, preparing conceptual design, developing preliminary safety and regulatory licensing, and establishing a financial plan for the waste treatment facilities.

Phase I, Part B will consist of constructing and operating separation and immobilization facilities to prove the concept of immobilization before treating the remaining waste in Phase II. Part B has been subdivided further into B-1 and B-2. Part B-1 will be in effect from August 24, 1998 through August 23, 2000, after which time Part B-2 will commence. During Part B-1, BNFL Inc. will confirm the design to about 25 to 30 percent complete, and start licensing activities for the facilities. Figure 1-1 indicates the relative maturity of the TWRS-P design. During Part B-2, BNFL Inc. is to complete the detail design and construct and operate these facilities to treat and immobilize approximately 10 volume percent of the radioactive liquid waste.

Figure 1-1. Status in Design Process.



1.1. Design Safety Feature Deliverable Requirements

1.1.1. Scope and Content

Included in the Part B-1 of the contract [Section C, Standard 4, Section c.2 (g)] is a requirement for a design safety feature (DSF) deliverable described as follows:

> "At six months from authorization to proceed with Part B-1, the Contractor shall submit to the DOE Regulatory Unit for review and comment (as defined in Table C4-2.1 of Section C of the Contract) a generic detailed description of the design safety features that will be incorporated into the waste treatment facility design. The description shall include the Contractor's approach to defense in depth and shall describe generic design features that are relied upon for safety and protection of the environment. The document shall describe design features, not consequences or risk analysis.
>
> Within two months from the authorization to proceed, and prior to the work commencing on the deliverable, the Contractor and the DOE Regulatory Unit shall develop and agree upon the scope and content of this design safety features deliverable."

The scope and content requirements for the design safety feature (DSF) deliverable were determined in working meetings between the DOE RU and BNFL Inc. in accordance with the contract and issued on October 22, 1998 as DOE letter 98-RU-0329 (DOE-RL 1998a). The attachment to this letter contains the scope and content for this deliverable which is identified as B1-33 in Table C4-2.1 of the contract. According to this scope, "The term 'generic' implicitly recognizes that at the time of the six-month submittal, not all structures, systems, and components (SSCs) will be fully defined because the design will be at a stage between conceptual and preliminary."

During development of the scope and content, it was agreed that BNFL would submit two types of information that would demonstrate the seven elements of an integrated safety management process to be used for the identification of the required DSFs. The two categories are defined in 98-RU-0329 as follows:

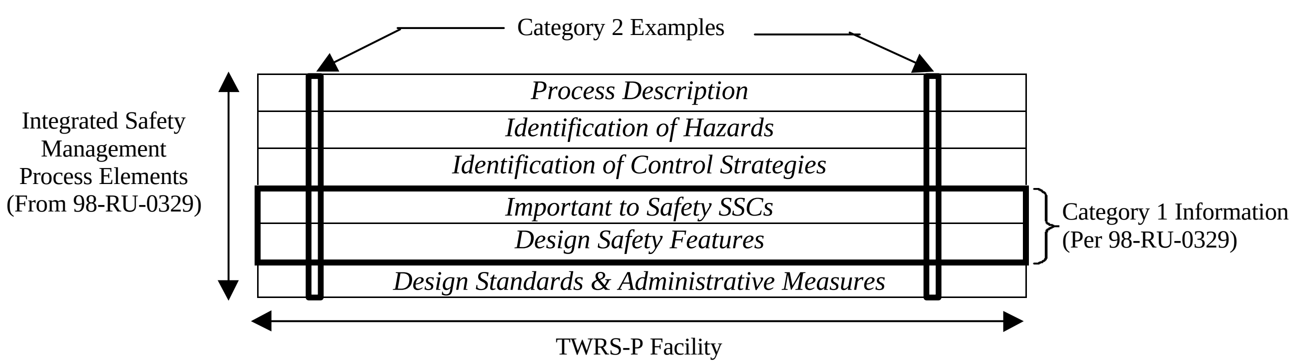
- "The first category is information that provides a description of planned DSFs intended at the date of the submittal (adequate scope information). It is recognized that information in this category may be preliminary. As such, the integrated safety management process described above will not be complete for all of the information supplied."

- "The second category is information that provides ten representative examples of the specific integrated safety management development of this information (adequate content information). This category is to demonstrate the integrated safety management design principles of the Contract. It provides assurance that the integrated safety management process is being completed adequately for the design."

The elements of the integrated safety management process as described in RU-0329 are summarized in Figure 1-2. The depth of Category 1 information can be described as shallow, primarily including only two elements as shown in the figure while its breadth is broad, encompassing all of the TWRS-P facility. Each example for Category 2 information has the depth of all elements in the figure but is narrow in scope, encompassing only one selected specific hazard event sequence.

The Category 1 Information in this deliverable includes some material on processes and hazard identification for clarity and ease of review. However, this deliverable excludes consequences and risk analysis in accordance with the instructions except in the Category 2 examples.

Figure 1-2. Relationship of Category 1 and 2 Information.



1.1.2. Compliance Matrix

The three DOE documents that form the basis of this deliverable are 98-RU-0329 which describes the scope and content, DOE/RL-0004 which describes the process, and DOE/RL-0006 which contains top level standards and principles.

In addition to the requirement for two categories of information, the scope and content document (98-RU-0329) contained several specific requirements that were used in the preparation of this deliverable. The compliance matrix in Table 1-1 shows which section in the DSF deliverable addresses each of the specific requirements. The location of the requirements in 98-RU-0329 is referenced by page and paragraph number. As shown in the matrix, compliance with the applicable top level standards and

PG[1]principles from DOE/RL-96-0006 (PG 2, ¶ 3) is addressed in the control strategy assessment which is documented in Section 3.X.5 for each example in the Category 2 information.

Table 1-1. 98-RU-0329 Compliance Matrix.

98-RU-0329			BNFL DSF DELIVERABLE [3]											
				Category 1			Category 2							
PG[1]	¶[2]	REQUIREMENT	1.0	2.0	Descriptions	Tables	3.0	3.X.1	3.X.2	3.X.3	3.X.4	3.X.5	3.X.6
1	2	Generic description of the design features that will be incorporated into the waste management treatment facility design.		X									
1	2	Describe of contractor's approach to defense in depth.		X			X						
1	2	Describe design features, not consequences or risk analysis.		X									
1 2	4 8	Generic detailed description of planned DSFs intended at the date of the submittal (may be preliminary).			X	X							
1	6	1. Identification of hazards and methodology used for identification of hazards.		X	X	X	X		X				
1	7	2. Identification of Hazard Control Strategies and the overall approach used to select/define these Control Strategies.					X			X			
2	1	3. DSFs required to implement Hazard Control Strategies.									X		X
2	2	4. DBE descriptions and justifications that these DBEs envelope known safety concerns.							X			X	
2	3	5. SSCs relied on to assure that consequences to the worker and the public from DBEs meet the Top Level Safety Standards and Principles (DOE/RL-96-0006) with adequate certainty and margin (i.e. SSCs relied on for safety).								X		X	
1 2	4 4	6. Measures taken or planned to assure that the SSCs identified in Item 5 will perform their function when called upon to do so with the requisite availability and reliability. These measures include design standards and administrative measures to be used to assure availability and reliability of the SSCs relied on for safety.		X	X	X					X		
2	5	7. Discussion of the process used for arriving at the measures identified in Item 6 and for establishing that such measures will be adequate for providing requisite availability and reliability.		X			X						
2	6	Items 5 & 6 comprise the "detailed description of the design safety features".	X	X	X	X				X	X		
2 3	9 6	Provide 10 representative examples of the application of the ISM process for DBE event sequences.					X						
3	1	Describe important-to-safety SSCs that are known or expected using level of detail available at time of submission.				X							
3	1	Include sufficient description of system and structure operations to understand the purpose of the DSFs.			X								
3	2	Describe SSCs which have not yet been classified as ITS but BNFL considers to be reasonable likely to be.				X							
3	3	Describe DSFs considered likely, based on existing design development and BNFL experience with similar facilities.		X		X							
3	3	DSFs shall be organized in sets associated with each ITS system or structure.				X							
3	3	Provide sufficient descriptive information to describe what the DSFs' specific purpose is and how they will achieve that purpose.				X							
3	4	Describe the manner in which the safety features relate to one another for each ITS SSC in as much detail as is known.		X									
3	6	Include mixture of consequence and frequency categories (high, low and intermediate).					X						
3	6	Impacts on public, workers, co-located workers, and environment shall be included.							X				
3	6	Describe items 1 through 7 (integrated safety management process elements) for each event sequence in the representative set:					X						
3	6	Include details concerning how the Standards Identification Process (DOE/RL-96-0004) has been implemented.					X						

Table 1-1. 98-RU-0329 Compliance Matrix.

98-RU-0329			BNFL DSF DELIVERABLE [3]										
				Category 1			Category 2						
PG [1]	¶ [2]	REQUIREMENT	1.0	2.0	Descriptions	Tables	3.0	3.X.1	3.X.2	3.X.3	3.X.4	3.X.5	3.X.6
3	6	Include details concerning how the Defense in Depth requirements (from DOE/RL-96-0006) has been implemented.		X			X					X	
3	7	Descriptions shall be as current as possible. BNFL Inc.shall specify the currency of the design in the submittal.	X										
3	7	All important to safety systems in the ISAR, at a minimum, shall be discussed.		X									
4	2	Approach to implementation of defense-in-depth shall describe the implementing procedures for the defense-in-depth implementing standards.					X					X	
4	2	The role of physical barriers, administrative controls, and design standards should be included.									X		
4	4	It is recognized the information provided in this submittal is preliminary and subject to revision by BNFL Inc.as part of the design process.	X	X			X						
4	5	Format for this deliverable shall be developed in working meetings between RU and BNFL.	X										
4	6	Identification of hazards will be based on comparison of the Part A and Part B1 PFDs.		X		X							
4	7	Discrepancies between Part A and Part B1 will be analyzed using BNFL HAZOP 1 methodology (key words) to identify new potential accidents.	X	X									
4	7	Discrepancies between Part A and Part B1 will be analyzed using severity levels based on unmitigated accident consequences.	X				X		X				
4	8	For each of the examples, specific control strategies will be identified for each hazard analyzed.								X			
4	9	BNFL Inc.approach to hazard control strategies definition will rely on proven BNFL engineering practices.					X			X			
4	9	Where mature control strategies exist for TWRS-P, hazard consideration of multiple alternatives to control the hazard is not necessary. To the extent that information on such considerations already exists, such information will be provided.								X			
4	9	Suitable justification for the use of the control strategy selected will be provided based on operational experience.								X		X	

[1] Page number in 98-RU-0329
[2] Paragraph number assigned to 98-RU-0329
[3] Section number in DSF deliverable

1.1.3. Evaluation of Changes From Part A to Part B-1

The information in this deliverable is based on the November 23, 1998 *Basis of Design* for the TWRS-P project. This design is approximately three months beyond the Part A conceptual design and represents approximately 3 percent completion. Design changes reflected in the PFDs were subjected to a mini-HAZOP 1 review to identify any new hazards introduced by changes since Part A. This submittal represents the BNFL Inc. approved design bases and assumptions for the TWRS-P facility which are preliminary and may be subject to further change as the design progresses. Changes will be evaluated using the process described in Section 3 of this deliverable, to determine if any changes need to be made to the hazards analysis, including the potential for new accidents and the severity levels resulting from the accidents. These will rely on the BNFL Inc. HAZOP 1 and 2 methodology with severity levels based on both unmitigated and mitigated accident consequences.

There have been three major changes from the Part A design:

- The new concept of three process buildings rather than one.
- New design concepts for equipment, as a result of breakthrough studies by BNFL Inc.
- Provision for the separation of the combined D and B waste streams into two separate streams.

In each of the ten examples in Category 2, differences between Part A and Part B-1 are specifically discussed.

1.1.4. Review and Approval by Project Safety Committee

The Project Safety Committee (PSC) provides advice to the TWRS-P Project General Manager on matters related to safety. The membership comprises functional managers from organizations such as ES&H, QA, Engineering, and Operations, in addition to specialists in select fields, and external members. The members are selected from several different organizations and backgrounds to ensure that the advice provided to the General Manager is representative of a broad evaluation of the matters under consideration. Section 2.2.2 of the ISAR includes specific actions required of the PSC. They are detailed in BNFL Inc.'s Code of Practice K70P526 (BNFL Inc. 1998d).

The PSC reviews the management and the performance of the TWRS-P facility nuclear, radiological, process, and occupational safety and environmental protection activities, such as unusual and off-normal incident reports, operating problems, and responses to Notices of Violations from the regulator. The PSC is also responsible for reviewing and recommending approval by the General Manager, or his designee, of safety-related documents including the control strategies and standards identified in this DSF Deliverable.

The PSC reviewed and recommended approval of this deliverable.

1.1.5. Project Contractor Representative Certification

The BNFL Inc. Project General Manager certifies this deliverable for submittal in accordance with DOE/RL-96-0004 with the full understanding that it will not become a part of the Authorization Basis, unless requested by BNFL Inc. and approved by the DOE RU.

1.1.6. Approach

In completing this deliverable, BNFL Inc. has taken a conservative approach entirely in keeping with the top level standards and principles, yet reflecting good, safe commercial practice expected in the privatization contract.

The approach is illustrated by the following examples taken from Category II. They represent three examples with differing cost/risk benefit results.

In the dropped load scenario (Section 3.3), BNFL Inc.'s control strategy cites the crane as Important to Safety. Its performance requirements have been very cautiously specified, pending further information being available on crane reliability. When that quality information has been established to support a less cautious specification, then BNFL Inc. will do so, and a significant saving in both capital and operating cost should result.

The second case relates to loss of cooling in the cesium storage vessel (Section 3.2). Evaluation of the various control strategies led to a wholly different, but preferable control strategy than initially envisioned after the first iteration. The final strategy increases the storage volume, enabling more dilute storage, thus precluding boiling. Thus an intrinsically safer, passive option has been developed. There will be an increase in capital cost in the tankage, but there should be a signifiant saving in both capital and operating cost associated with not guaranteeing the cooling water service.

Finally, in the example dealing with carrier breakout from the pneumatic sample transfer system (Secton 3.6), certain specific aspects of the control strategy (relating to integrity of the sample bottle) have been included to significantly reduce the risk – even though the reliability target was easily achieved. This is an excellent example of investing a modest amount of money to bring about a substantial safety benefit.

1.2. Environmental, Safety, and Health Program

1.2.1. Policy for Safety

The company considers that none of its activities is more important than the health and safety of its employees, its contractors, the general public, and the protection of the environment. Integrated safety management is a key element for implementation of this safety policy.

As a minimum, the company will comply with all relevant legislation and in some cases may go beyond legal requirements.

The company will ensure that its operations are performed, and can be seen to be performed safely.

The company will endeavor to prevent accidents and to minimize, as far as reasonably practicable, the consequences of any accident which may occur. The company will delegate an appropriate level of authority on safety matters to managers in groups and units.

The company will ensure that there are effective procedures for consultation on health and safety matters with representatives of the company’s employees.

The company will ensure that there are satisfactory arrangements for consultation with appropriate external representatives on health and safety matters which may be of concern to the population in the vicinity of each works.

The company will make available to its workforce, the general public, and their representatives such information as is appropriate in relation to their health and safety and to the protection of the environment including any event or incident which is deemed to be of possible concern to them.

In order to move towards a system of self-regulation, the company will continue to develop, implement and maintain a structured safety managnement system. Compliance with all aspects of this Health and Safety Policy will be subject to audit.

1.2.2. Environmental Radiation Protection Program

BNFL Inc.'s Environmental Radiation Protection Program (ERPP) documents the program standards, requirements, administrative controls, responsibilites, and authorities for protecting the public health and safety and environment from radiological hazards associated with the TWRS-P facility during normal operations. The ERPP addresses the following elements and additional requirements of SRD Volume II, Section 5.3, "Environmental Radiation Protection," and Section 5.4, "Environmental Radiological Monitoring," as appropriate:

1. Activities and areas of the site subject to the ERPP
2. Measures to be used to implement the ERPP
3. Methods to be used to monitor, report, and record compliance with the ERPP
4. Models and methods used for dose assessment including bioaccumulation and dose-conversion factors
5. As Low As Reasonably Achievable (ALARA) Program
6. Effluent and environmental monitoring
7. Groundwater protection
8. Radiological protection in the management of radioactive waste
9. Controls on the release of materials
10. Property containing residual radioactive materials.

The outline for the ERPP is included in the ISAR as Appendix 5B, "Environmental Radiation Protection Program Outline".

1.2.3. Safety and Health Program

BNFL Inc. considers that none of its activities is more important than the health and safety of its employees, its contractors, the general public, and the protection of the environment. The TWRS-P design will include conservative margins that allow operations to continue after unplanned excursions from normal conditions before requiring corrective actions and taking into consideration the potential degradation of elements and operational errors. The authorization basis will include these margins.

For facilities designed and built by BNFL Inc., a proven method for identifying the requirements of operational and engineered protective measures is undertaken, the results of which are applied during the entire project design phase. The BNFL Inc. approach to facility design applies a suite of company targets to facilitate compliance with BNFL Inc. standards and compliance with applicable radiological exposure standards. Where practical, passive features are used rather than active features. Potential faults are minimized by a design that moves the facility towards a safe state in response to failures, or by incorporating permanently available, passive features that render the facility safe following a failure. In some cases, however, it may be necessary to incorporate active engineered features into the design of a facility that act in response to the fault to render the facilty safe.

Based on the design information and the suite of potential safeguards (controls) identified in the Hazards Analysis Report (HAR), the Requirement Identification Team Subject Matter Experts identified and developed TWRS-P Safety Criteria, implementing consensus codes and standards, and subordinate standards. A comprehensive description of the integrated safety management process and the standards identification process are contained in BNFL-5193-SRD-01, *Safety Requirements Document*, Appendix A of Volume II. The set of standards is reflected in BNFL-5193-SRD-01, *Safety Requirements Document*, Volume II.

The sources of standards used to develop the SRD Safety Criteria include statutory requirements and contractual requirements and agreements, as necessary to ensure consistent and effective interactions with other contractors on the Hanford Site. Additionally, US Nuclear Regulatory commission (NRC) regulations, US Department of Energy (DOE) directives, and other sources of standards were reviewed to identify additional requirements related to radiological, nuclear, and process safety necessary to ensure adequate protection of workers and the public from hazards posed by the TWRS-P Facility. The sources of requirements and guidance included the following:

1. Regulations directly applicable to the TWRS-P Facility (e.g., 10 CFR 830.120, 10 CFR 835, and Washington Administrative Codes)

2. Regulations applicable to industries handling hazardous chemicals (e.g., 29 CFR 1910.119 and 40 CFR 68)

3. Contractually mandated sources (primarily DOE/RL-96-0006)

4. Regulations and derived practices for commercial nuclear facilities (e.g., 10 CFR 20, 10 CFR 72, and 53 FR 13276, proposed revision to 10 CFR 76)

5. DOE directives (e.g., DOE O 420.1, DOE-STD-1020, and DOE-STD-1021)

6. Personnel and corporate expertise related to commercial chemical and nuclear industry safety objectives and practices.

Items 1, 2, and 3 were considered as requirements and items 4 through 7 were considered as sources of guidance. A complete list of documents reviewed and justification for consideration of the documents for SRD development are presented in Attachment D of BNFL-5193-SRD-01, *Safety requirements Document*, Volume I.

1.3. Quality Assurance Program

BNFL Inc.prepared its "TWRS-P Project Quality Assurance Program and Implementation Plan" (QAPIP) (BNFL Inc 1997) specifically for work performed on or for the Tank Waste Remediation System – Privatization project for the Part B scope of work. This QAPIP is in conformance with 10 CFR 830.120, "Quality Assurance Requirements," and with the principles stipulated in DOE/RL-96-0006, *Top Level Radiological, Nuclear, and Process Safety Standards and Principles for TWRS Privatization Contractors*.

The BNFL Inc. team uses its quality assurance program as an important tool in achieving the goal of safe operation of the TWRS-P facility. The Quality Assurance Program (QAP) describes the organizational structure, functional responsibilities, levels of authority, and interfaces for those managing, performing, and assessing the work to be performed. Integration of the QAP for the TWRS-P project began during the initial phases of the project and continues during design, procurement, construction, startup, testing, inspections, operations, maintenance, modifications, and deactivation of the facility. Administrative processes such as training, procedure development, and configuration management are subject to the requirements of the QAP.

Quality assurance and quality control shall be applied throughout all phases of the project and to all activities affecting quality associated with the facility as part of a comprehensive system to ensure that all items delivered and services and tasks performed meet applicable requirements. The program requires periodic assessments of activities from design through deactivation. System audits are conducted to objectively evaluate the effectiveness and proper implementation of the QAP for activities affecting quality of SSCs. Surveillance of specific project activities (e.g., process controls, preparation of safety documentation, configuration and document control, and records management) is conducted to supplement the compliance audit program to quickly determine compliance of activities to program requirements.

Selected QAP elements shall be applied to BNFL Inc. suppliers and subcontractors performing work for the TWRS-P Project Part B activities beginning early in the project with long lead procurements. A graded approach to application shall be used to flow down QAP requirements. The QAP provides the direction to project functional groups for identifying the quality attributes necessary for planning, performing, and subcontracting work in a manner that will provide the optimum safety and optimum quality of tasks and deliverables.

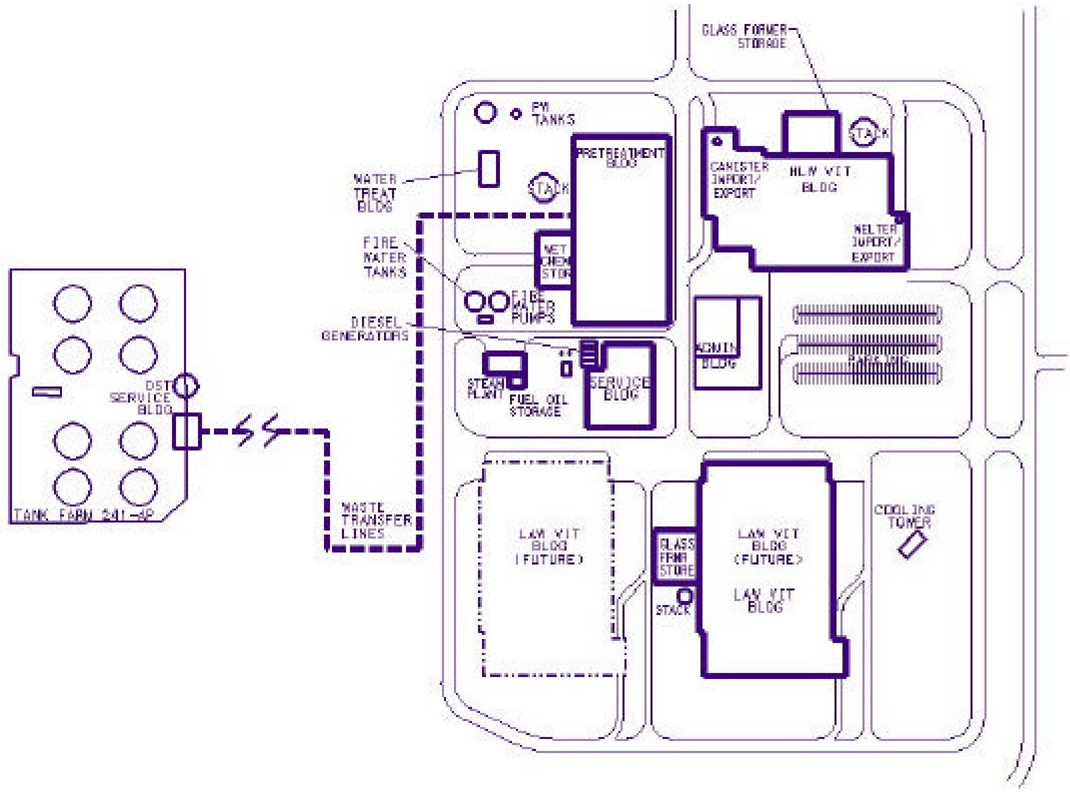
BNFL Inc. endorses a quality improvement culture and encourages TWRS-P personnel to identify quality, safety and health, and environmental compliance concerns to their supervisor and management for action and disposition. BNFL Inc. management at all levels is committed to continuous improvement of TWRS-P project activities and processes and to providing the training, resources, and support necessary to ensure safe, effective, and efficient implementation of TWRS-P policies, plans, and work performance.

1.4. Facility Description

The TWRS Privatization facilities will occupy approximately 55 acres of land in the 200 East Area of the Hanford Site in Richland, Washington. Existing facilities in close proximity to the proposed site include the formerly used Grout Treatment Facility, A Tank Farms Complex, the Plutonium Uranium Extraction (PUREX) Plant, and several underground cribs (low level radioactive liquid waste percolation field).

As shown in Figure 1-3, the TWRS-P facility will include 12 primary buildings. The three main process buildings contain most of the hazardous operations which include major areas for pretreating (Pretreatment Building) and immobilizing tank waste (LAW Vitrification Building and HLW Vitrification Building). Other smaller support buildings (i.e. Wet Chemical Storage Building and Glass Former Storage Building) provide for storage or transfer of hazardous materials.

Figure 1-3. Facility Layout.



Electrical power to the TWRS-P facility will be supplied through two power transformers from two independent 230 kV transmission lines The transformers deliver a 13.8 kV secondary voltage for the facility internal distribution. The TWRS-P facility will be divided into two power load groups, A and B. It is intended that each transformer will normally supply the load assigned to its own load group, however, each transformer will have adequate rating to carry both A and B in case of loss of a single transformer or its feeder.

The following is a brief description of these primary buildings.

1.4.1. Pretreatment Building

The Pretreatment Building is important to safety (ITS) because it protects the pretreatment processes from external events, provides biological shielding, ventilation paths and maintains configuration so that other ITS systems can perform their safety functions. It will be approximately 440 x 220 x 140 feet high with an embedment of some 50 feet into the ground. The embedded portion of the building structure will be of reinforced concrete construction, whereas, the superstructure will be of structural steelwork with metal roof. The process cells will be reinforced concrete, typically 4 feet thick providing radiation protection to facility operators. Each cell floor and a portion of the walls will be lined with stainless steel cladding to assure secondary containment, sloping to collection sumps. The building structure will be supported by a reinforced concrete mat foundation.

Ventilation systems for the Pretreatment Building will support containment and confinement of sources of contamination, principally by airflows and pressure differentials designed to promote airflow from areas of lesser contamination potential to areas of greater contamination potential.

The Pretreatment Building will contain the standard plant instrumentation for process measurement such as flow measurement and level measurement for process plant and position sensing for mechanical handling plant. It includes the measuring device, transducers, transmitters and other associated electronics. These SSCs will normally interface to a system for control or directly to an operator interface device for a non-automated plant.

1.4.2. LAW Vitrification Building

The LAW Vitrification Building is important to safety because it protects the LAW vitrification process from external events, provides biological shielding, ventilation paths and maintains configuration so that other ITS systems can perform their safety functions. It will be approximately 500 ft x 260 ft x 110 ft high with an embedment of some 15 ft into the ground. The embedded portions of the building structure will be of reinforced concrete construction, whereas, the superstructure will be of structural steelwork with metal roof. The building structure will be supported by a reinforced concrete mat foundation.

The LAW Vitrification building contains three vaults (“caves”) where the LAW melters are located. To provide radiological protection, the caves have reinforced concrete walls up to 3 ft thick. Lead glass windows and remote camera systems for operator viewing are incorporated into the cave walls. The caves are also equipped with special purpose in-cave cranes and servo-manipulators for cave operations and maintenance.

Ventilation systems for the LAW Vitrification Building will support containment and confinement of sources of contamination, principally by airflows and pressure differentials designed to promote airflow from areas of lesser contamination potential to areas of greater contamination potential.

The LAW Vitrification Building will contain the standard plant instrumentation for process measurement such as flow measurement and level measurement for process plant and position sensing for mechanical handling plant. It includes the measuring device, transducers, transmitters and other associated electronics. These SSCs will normally interface to a system for control or directly to an operator interface device for a non-automated plant.

Two power transformers are provided to step down the incoming 13.8kv power to 4.16kv. The 4.16kv power feeds the LAW melter electrodes through voltage adjustment equipment. Commercial grade standby diesel generators support melter-related loads for important protection purposes. These diesels start and acquire loads manually by operator actions.

1.4.3. HLW Vitrification Building

The HLW Vitrification Building is important to safety because it protects the contained HLW processes from external events, provides biological shielding and ventilation paths, and maintains configuration so that other ITS Systems can perform their safety functions. It will be approximately 460 ft x 320 ft x 110 ft high with an embedment of some 20 ft into the ground. The embedded portion of the building structure will be of reinforced concrete construction, whereas, the superstructure will be of structural steelwork with metal roof. The building structure will be supported by a reinforced concrete mat foundation. The building will contain two special purpose reinforced concrete vaults termed ‘caves’ where the HLW melters are loaded. To provide radiological protection, the caves have reinforced concrete walls up to 5 ft thick. Lead glass windows and remote camera systems for operator viewing will be incorporated into the cave walls. The melter caves will be fully lined with stainless steel cladding for contamination control and to allow periodic system washdown and will be equipped with special purpose in cave cranes and servo-manipulators for cave operations and maintenance. Other caves are provided with extensive decontamination and maintenance bays for process equipment, manipulators and process crane maintenance.

The ventilation systems for the HLW Vitrification Building will support containment and confinement of sources of contamination, principally by airflows and pressure differentials designed to promote airflow from areas of lesser contamination potential to areas of greater contamination potential.

The HLW Vitrification Building will contain the standard plant instrumentation for process measurement such as flow measurement and level measurement for process plant and position sensing for mechanical handling plant. It includes the measuring device, transducers, transmitters and other associated electronics. These SSCs will normally interface to a system for control or directly to an operator interface device for a non-automated plant.

Two power transformers are provided to step down the incoming 13.8kv power to 4.16kv. The 4.16kv power feeds the LAW melter electrodes through voltage adjusted equipment. Commercial grade standby diesel generations support melter related loads for important protection purposes. These diesels start and acquire loads manually by operator actions.

1.4.4. Administration and Service Buildings

These are multistory steel structures with insulated metal exterior walls and environmental control equipment to house personnel. The primary function of these buildings is to provide accommodations for operations, maintenance and support personnel. These buildings will contain offices and meeting facilities as well as shops for maintenance functions. The combined buildings will be approximately 27,000 square feet on two levels. Since there are no hazards associated with the buildings that require protection against natural phenomena hazards, the building will be designed to commercial standards through utilization of the Uniform Building Code.

1.4.5. Diesel Generator Building

This is a reinforced concrete structure to contain emergency power to support safe shutdown of the facility during loss of off-site power. The structure will be designed to withstand the most severe natural phenomena hazards in order to continue to function during those defined events. It will also contain adequate fuel for to support back-up power needs as defined by process system requirements.

1.4.6. Wet Chemical Storage

This is a chemical storage facility to contain and/or control hazardous chemicals. Process equipment and controls will be provided within the facility to transfer chemicals to the process facilities as well as supporting off-loading of bulk chemicals. The facility will include an insulated, metal frame and climate controlled structure for pre-packaged chemical storage. Covered chemical storage tanks with containment dikes will be located adjacent to the facility. There are no hazards associated with the facility, which require protection against natural phenomena hazards; therefore, the building will be designed to commercial standards utilizing the Uniform Building Codes.

1.4.7. Glass Former Storage

This is a structural steel building for storage and transfer of the constituents required for formation of the glass canisters. Since there are no hazards associated with the facility, which require protection against natural phenomena hazards, the building will be designed to commercial standards through utilization of the Uniform Building Code.

1.4.8. Steam Plant

This facility will contain storage facilities and processing facilities to provide steam to support waste treatment. The equipment will be protected against inclement weather and foreign material by a metal frame steel structure with light weight metal siding. Since there are no hazards associated with the process greater than what is typical for similar commercial facilities, the building will be designed to commercial standards through utilization of the Uniform Building Code.

1.4.9. Cooling Tower Basin

This is a forced draft, water to air exchange cooling tower to provide cooling for chemical processing systems. The structure will consist of concrete retention basins and the forced draft, cooling tower. Transfer pumps will also be provided to circulate the cooling water supply.

1.4.10. Water Treatment Plant

This is a structural steel building of approximately 2800 square feet, to house chemical treatment equipment for treating the raw water supply stream. The facility will contain storage facilities outside the structure for water storage tanks. Since there are no hazards associated with the facility, which require protection against natural phenomena hazards, the building will be designed to commercial standards through utilization of the Uniform Building Code.

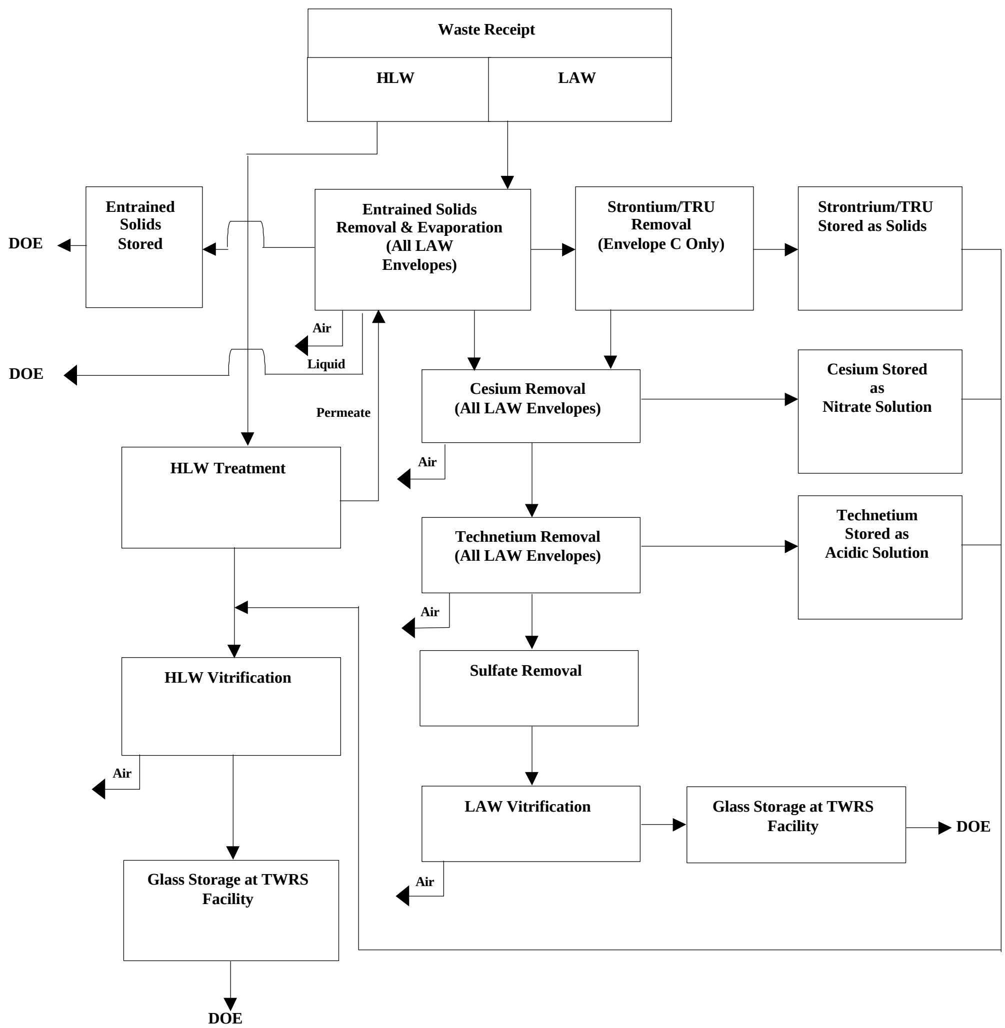
1.4.11. Fire Water Tank and Pump House

This is a light weight steel structure with rated fire wall to protect the fire protection equipment from inclement weather and provide pressurization of the fire protection system within the processing facilities. Storage tanks will be provided of adequate capacity to support systems requirements.

1.5. Process Description

As indicated in the simplified process flow diagram shown in Figure 1-4, the TWRS-P facility will contain processes for pretreating and immobilizing both LAW and HLW. Characterized waste will be transferred from the DOE-operated DST system to a BNFL Inc. TWRS-P Facility through double-contained transfer pipes with a leak-detection system. The waste is transferred to one of two feed receipt tanks (HLW or LAW) that stage the waste prior to pretreatment.

Figure 1-4 . Simplified TWRS-P Process Flow Diagram.



The LAW feed is transferred from Tank 241-AP-106 to the facility through a co-axial pipeline to Vessel V12001 and Vessel 12002. This waste provides the basis for the material at risk (MAR) used in LAW line break example. The LAW feeds consist of three envelopes that designate the major types of the liquid tank waste:

- Envelope A characterizes the largest category of the waste. This LAW feed contains ^{137}Cs and ^{99}Tc at concentrations that require removal to comply with LAW glass specification and contains glass limiting constituents (e.g. sulfate) that must be removed.

- Envelope B characterizes a small fraction of the waste that has higher ^{137}Cs concentrations and contains more glass-limiting constituents (e.g., sufate, chloride, and phosphate) as compared to Envelope A.

- Envelope C characterizes waste that is high in organic carbon. The organic carbon results in higher ^{90}Sr and TRU concentrations than Envelope A and Envelope B and slightly lowers the amount waste in the glass as compared to Envelope A. Envelope C also contains sulfate requiring removal prior to vitrification.

The HLW slurry will contain a mixture of liquids (Envelopes A, B or C) and solids (Envelope D). Envelope D will be delivered by pipeline from DOE into a receipt vessel located in the process building.

1.5.1. Pretreatment

Pretreatment of the LAW includes process steps for reducing radionuclide concentrations and the volume of waste being fed to the LAW treatment system. Pretreatment of LAW includes removing entrained solids, strontium/transuranic (TRU) compounds, cesium, technetium, and sulfate from the feed to ensure the radionuclide limits in the LAW glass are met. These removed constituents, with the exception of entrained solids and sulfate, are incorporated into the HLW melter feed. Entrained solids are returned to DOE or incorporated in the HLW melter feed. Removed sulfate is transferred to DOE for disposition.

The HLW sludges are received via a separate route from the LAW. HLW is transferred from the DOE-operated tank system to the three HLW receipt vessels, which receive the waste prior to pretreatment. Following receipt, the HLW feed is sent to the ultrafiltration vessels to separate HLW solids. In the ultrafiltration vessels, solids from the receipt tanks will be concentrated to 25% by weight. Permeate from the ultrafiltration vessel is combined with the LAW feed. The solids concentrate is washed and stored in the three sludge storage vessels. The washed sludge is mixed with LAW ultrafiltration and ion exchange products from the LAW pretreatment system. This slurry is transferred to the HLW vitrification system.

<u>LAW Feed Evaporator</u>

The LAW feed stream is evaporated in the LAW Feed Evaporator to provide a consistent feed concentration and minimize the volume throughput of the pretreatment process. The LAW Feed Evaporator is a continuous, submerged-tube, forced-circulation evaporator that concentrates the feed to provide a consistent feed for the ion-exchange process. The LAW feed is recirculated at a high flow rate through the evaporator reboiler until the sodium content of the stream reaches the desired concentration. The concentrated LAW is then pumped to a buffer vessel before entrained solids are removed. The vapor stream is condensed and the condensate routed to the shared active condensate tanks, which receive condensate from several evaporators in the LAW pretreatment process. The condensate is sampled, analyzed, and transferred to a permitted storage and treatment facility located at the Hanford Site.

<u>Ultrafiltration</u>

Following evaporation, the concentrated LAW is sent to the ultrafiltration vessel to separate entrained solids. In the ultrafiltration vessel, solids from the receipt tanks will be concentrated to 20% by weight. These solids are concentrated and washed prior to being discharged for interim storage for eventual return to the USDOE. The permeate from the entrained solids is transferred to the cesium ion exchange process. For envelope C type wastes there is a requirement for an additional operation to separate strontium and technetium. Strontium and technetium are removed from the waste envelope by a precipitation process. The precipitate is concentrated and washed prior to being sent for interim storage. These solids are eventually mixed with cesium and technetium eluates from the ion exchange process, and incorporated into the HLW melter feed.

Ion Exchange

To meet ILAW specifications, the radioactive cesium and technetium content of the LAW feed must be reduced. Permeate leaving the ultrafiltration vessel enters the ion-exchange system. Reduction of cesium and technetium is accomplished by passing the feed through successive ion-exchange systems. The two systems are separated by buffer tanks to contain any breakthrough of cesium. Cesium is removed first, then technetium is removed. Both systems have two sets of ion-exchange columns in parallel. Each set has two columns in series. One set is processing feed while elution and regeneration are occurring on the other set. When cesium or technetium has reached the predetermined loading or has been detected in the effluent from its respective columns, the flow to that set of columns is suspended, and the LAW is diverted to another set of columns.

The cesium and technetium subsequently are removed from the loading columns, and the resin is regenerated for reuse. The cesium resin has an anticipated useful life of at least 10 cycles, after which the spent resins are removed from the columns and replaced with fresh resin. The spent resins will be either processed in the LAW melter, or disposed of as a solid waste in accordance with applicable regulations. Following removal of cesium and technetium, sulfate from the feed is removed, if required, by a further process step. (The sulfate removal process is subject to evaluation and may be required to ensure glass incorporation limits are met)

The cesium and technetium eluted from the ion exchange columns is sent for nitric acid recovery. The purpose of the nitric acid recovery is to recover nitric acid for re-use and to reduce the storage volumes of the cesium and technetium liquid stream. The cesium and technetium pass through separate, identical systems. An evaporator kettle is used to concentrate the cesium and technetium. The concentrated cesium and technetium is stored prior to blending with the HLW and separated strontium/TRU stream.

Feed Concentration

The LAW vitrification feed preparation system concentrates the waste following ion exchange. The evaporator concentrates the waste to reduce the volume of waste processed through the LAW melters. The concentration of the product is controlled to avoid precipitation of soluble metals. The pretreated waste is discharged to concentrated LAW holding tanks, sized to accommodate two day's quantity of feed, receive the concentrated solution from the evaporator. This solution is then transferred to one of two 1-day storage tanks in the LAW vitrification building.

High Level Waste Component

The HLW sludges are transferred from the USDOE via a separate route from the LAW. HLW from the DOE-operated tank system is transferred to the three HLW receipt vessels, which receive the waste prior to pretreatment. Following receipt, the HLW feed is sent to the ultrafiltration vessel to separate HLW solids. In the ultrafiltration vessel, solids from the receipt tanks will be concentrated to 20% by weight. Permeate from the ultrafiltration vessel is combined with the LAW feed. The solids concentrate is washed and stored in three sludge storage vessels. The washed sludge is mixed with the LAW ultrafiltration and ion exchange products from the LAW pretreatment system. This slurry is transferred to the HLW vitrification system.

Pretreatment Emission Control

Within the pretreatment facility, there are gaseous emissions that arise from the fluidic transfer devices and agitators, exhausters, evaporator overheads, ejector transfers, and filling/emptying of vessels. These pretreatment emissions are passed into the vessel vent system and are treated in an emissions treatment system. These emissions are passed through one of two high efficiency mist eliminators (HEMEs) to remove entrained droplets and particulates. The emissions are routed to a counter current scrubbing column. The purpose of this scrubber is to clean the emissions stream. Scrubber liquor will collect in an integral sump, and will be recirculated to the top of the scrubbing column. Levels of radionuclides, acid gases, and other water-soluble contaminates are lowered in the scrubber.

After leaving the scrubber column, the emissions pass through the HEPA preheater where the emission stream is heated to above dewpoint to prevent condensation within the HEPA filters. After heating, the emissions pass through HEPA filtration. The cleaned emissions stream is released through the building stack.

1.5.2. LAW Vitrification

The LAW vitrification process consists of the following three process:

- Addition of glass-forming chemicals and mixing
- Vitrification of the LAW and glass-forming chemical mixture in a joule-heated melter
- Melter offgas cleanup.

Nine glass-forming chemical additives will be used in developing the LAW glass recipe. These are silica, alumina, boric acid, calcium silicate (wollastonite), ferric oxide, lithium carbonate, magnesium silicate (olivine), zircons, and zinc oxide. These chemicals are placed in storage silos prior to incorporation into the LAW melter feed. From the storage silos, the dry chemicals are weighed and transferred into pneumatic blending silos. The blending silos use compressed air to blend a 24-hour batch of dry chemicals for each LAW melter. Two blending silos are provided for each melter. One silo is blending while the other is sampled and analyzed to confirm that the blend is within specification. After blending, the glass formers are transferred to a feed hopper within the main facility until required for use. There is a glass-former feed hopper for each melter sized for 8-hour capacity.

Following process-related sampling and analysis, the concentrated waste is combined with glass-forming chemicals and mixed. This material is transferred as slurry to the LAW melter feed tanks to provide continuous feed onto the cold cap of each of the three LAW melters. The three electric-powered, joule-heated LAW melters operate in parallel. Each melter has a normal capacity of 10 metric tons (Mt) of glass per day. The operating temperature of the melter is approximately 1050-1200°C. The LAW feed in the melter forms a cold cap on the surface of the melt as the feed enters the melter. Air bubblers transfer compressed air through the molten glass and increase circulation of the mixture. This agitation improves heat transfer, rate of reaction, and the production rate of the melter. The exterior surfaces of the melter are water cooled to minimize migration of molten glass within the refractory.

Water is evaporated off the cold cap and released to the offgas system as superheated steam. The feed components undergo chemical reaction, are converted to their respective oxides, and are dissolved in the melt. As these materials are heated, superheated gases are released into the melter offgas system. Volatile feed components are also carried to the offgas. The solids and nonvolatile components entrained in the offgas are captured in the quench unit and scrubber, and are recycled back into process. The selective reduction (SCR) unit, condenser, and scrubber components of the offgas treatment system treat volatile constituents remaining in the offgas after the quench.

Molten glass is discharged to metal containers for cooling, solidification, and storage. The process yields a durable glass containing the immobilized LAW. The glass is cooled, and the container is sealed, decontaminated, and stored for approximately 30 days before transfer to DOE.

1.5.3. HLW Vitrification

The HLW vitrification consists of the following processes:

- Addition of glass-forming chemicals and mixing
- Vitrification of the HLW and glass-forming chemical mixture in a joule-heated melter
- HLW melter offgas treatment.

Five chemical additives will be used in developing the HLW glass recipe, including silica, boric acid, calcium silicate (wollastonite), ferric oxide, and lithium carbonate. These chemicals are placed in storage silos prior to incorporation into the HLW melter feed. From the storage silos, the dry chemicals are weighed and transferred into pneumatic blending silos. The blending silos use compressed air to blend dry chemicals for each HLW melter. Two blending silos are provided for each melter. One silo is blending while the other is sampled and analyzed to confirm that the blend is within specification. After blending, the glass formers are transferred to a feed hopper within the main facility until required for use.

Waste feed is then transferred to the HLW melter feed vessel, which feeds directly to the online HLW melter. The HLW melter feed vessel is sized to accommodate a day’s quantity of feed. The melter has a nominal capacity of 1.5 Mt of glass per day. The operating temperature of the melter is approximately 1100 – 1200 °C. The HLW feed in the melter forms a cold cap on the surface of the melt as the feed enters the melter. Air bubblers provide agitation of the molten glass and this improves heat transfer, rate of reaction, and product quality of the glass produced. The exterior surfaces of the melter are water cooled to minimize migration of molten glass within the refractory.

Water is evaporated off the cold cap and released to the offgas system as superheated steam. The feed components undergo chemical reaction, are converted to their respective oxides, and are dissolved in the melt. As these materials are heated, superheated gases are released into the melter offgas system. Volatile feed components are also carried into the offgas. The solids and nonvolatile components entrained in the offgas are captured in the offgas treatment system, and are recycled back into the process. Volatile constituents remaining in the offgas may be removed by the condenser and scrubber components of the offgas treatment system. Molten glass is discharged continuously to metal containers for cooling, solidification, and storage. The process yields a durable glass containing immobilized HLW.

Canister/Containers will be stored in single stacks for maximum duration of 60 days. Canister/Container movements within the Product store will be remotely operated.

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